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SAO NOTE 23

ESTABLISHMENT OF BUFFER ZONE FOR BULK STORAGE OF COMMON CHEMICAL COMPOUND

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

DA and GSA have recommended that certain parcels of land located adjacent to the new acid area at Volunteer AAP be declared excess. Attempts were made to provide rationale for retention of this area based on the need for a safety buffer zone. This rationale was not accepted by DA since there is no formal policy in regard to buffer zones around areas containing bulk storage of common chemical compounds. This report describes the rationale and methodology used to establish hazard distances from which buffer zone policy can be established.

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INTRODUCTION

The Department of the Army (DA) and the General Services Administration (GSA) have recommended that certain parcels of land located adjacent to the new acid area at Volunteer Army Ammunition Plant be declared excess. Attempts were made to provide rationale for retention of this area based on the need for a safety buffer zone to protect the public from personal injury or damage to property in case of chemical mishap. This rationale was not accepted by DA since there is no formal policy in regard to buffer zones around areas containing bulk storage of common chemical compounds.

Consequently, the ARMCOM Safety Office requested that a study be performed from which buffer zone policy could be derived. This report describes the rationale and methodology used to establish hazard distances.

APPROACH

A survey was conducted to identify the chemical compounds stored in bulk quantities (5000 lbs or more) at the Army Ammunition Plants and Arsenals. The purpose was to establish pertinent details of their storage configuration that would have a bearing on the severity of potential hazards if an accident would occur.

Five major compounds were identified: Sulfuric Acid, Nitric Acid, Acetic Acid, Acetic Anhydride,and Ammonia. A consideration of the types of historical accidents led to the conclusion that the "worst-case" threat would occur if a storage tank would rupture and spill its contents onto the ground and into the atmosphere. Since regulations require that all bulk storage areas be surrounded by dikes, the volume of compound within the storage tanks is assumed to be contained in the area defined by the dikes once a spill occurs.

Once the chemical compounds are identified, the maximum downwind distance (hazard-distance) at which a human physiological threat exists can be calculated based on the concentration/time of exposure (dosage), the area of the resulting spill, the rate of evaporation of the hazardous compound from the spill puddle, the evaporation time (or time to decontamination), and the prevailing meteorological conditions. This analysis was performed using worst-case meteorological conditions.

METEOROLOGICAL FACTORS

Meteorological conditions prevailing during an incident in which chemical compounds are released have a major influence in determining the resulting concentration of the vapor cloud at any downwind distance. For large spills, the rate at which the liquid evaporates is a function of temperature and windspeed. Subsequent diffusion and the dilution of the vapor cloud formed by the evaporating liquid are governed by atmospheric stability and windspeed.

Broad inferences on stability can be made according to the time of day: inversion at night, neutral around sunrise and sunset, and lapse during the major portion of the daylight period. These terms are defined by the difference between the temperature at 4 meters and at 1/2 meter above the ground ($\Delta T = T_{4m} - T_{0.5m}$, in °F). The ΔT values used for the calculations are: -2 for lapse, 0 for neutral, and +2 for inversion. This selection of discrete values of ΔT covers a wide range of atmospheric stabilities and can be considered generally to bracket a high percentage of the occurrences in nature.

The rate of evaporation is affected by windspeed, and the diffusion of the vapor cloud is affected by both windspeed and stability conditions. To determine the worst-case meteorological condition, a search was made over the expected range of these variables. Using the transport and diffusion model outlined in ORG 40[1], it was determined that the worst-case condition occurred at the 2 mph windspeed with an inversion stability condition. For the remaining meteorological variable, temperature, 86°F was chosen as representative of the high extreme for night time (inversion) conditions.

SPILL AREAS

No historical data was available on the size (area) of spills that have occurred. A spill could result if a seal would fail at a connection or valve. Depending upon the period of time until the leak is discovered, the resulting puddle could vary from a few to several hundred square feet. If a large storage tank would rupture, the resulting puddle could cover several thousand square feet. In order to cover the expected area for most spills, calculations were made for each compound for puddle sizes of 200, 400, 600, 800, and 1,000 square feet.

EVAPORATION RATE

The method for calculating the evaporation rates for liquid compounds was taken from the Chemical Engineers' Handbook, 3rd Edition, Section 8 (General Theory of Diffusional Operations).

The procedure used for the calculations is outlined in Appendix A. Table 1 shows the molecular weights and volumes that entered into the calculations of the diffusivities and mass transfer coefficients:

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[1] Irving Solomon et al, ORG Report 40, Methods of Estimating Hazard Distances for Accidents Involving Chemical Agents, February 1970. CONFIDENTIAL.

TABLE 1. MOLECULAR WEIGHTS AND VOLUMES

Compound	Molecular Weight	Molecular Volume	Vapor Pressure
Sulfuric Acid	98.0	81.0	3.2
Nitric Acid	63.0	55.3	77.0
Acetic Acid	60.0	68.4	656.0
Acetic Anhydride	102.0	117.4	7.8
Ammonia	17.0	26.7	8770.0

Assuming a 2 mph windspeed and a temperature of 86°F, the evaporation rate for each compound is shown in Table 2 for varying puddle size.

TABLE 2. EVAPORATION RATES (LBS/MIN)

Compound	Spill Area (Sq. Ft.) 200	400	600	800	1000
Sulfuric Acid	0.0766	0.143	0.206	0.267	0.326
Nitric Acid	1.358	2.535	3.652	4.73	5.78
Acetic Acid	10.5	19.6	28.3	36.6	44.7
Acetic Anhydride	0.176	0.328	0.472	0.612	0.748
Ammonia	60.66	113.3	163.2	211.4	258.3

For the purposes of this analysis, it was assumed that the compounds evaporated in a pure state and did not break down or combine with other elements to form different compounds. No attempt was made to determine the amount of sulfur oxides or nitrogen oxides that could form and pose a threat in themselves.

TOXICOLOGY

Historically, buffer zones were usually established by first choosing the percentile of the population that is to be protected, then computing the corresponding dosage for that percentile from dose-response curves, and finally, determining the required distances by using appropriate transportation and diffusion models. However, there is little data available for human physiological response to common chemical compounds. In order to establish safe distances (i.e., required buffer zones), it is necessary to first select the hazard dosage, i.e., the effects-level, to be considered. Among the factors which pertain to the effective dosage, the most important are concentration of the materiel, duration of exposure, and sensitivity of human tissues and organs. Attempts to obtain dose/response data for the five compounds considered within this study proved unsuccessful. Contacts made with Edgewood Arsenal, AMC Surgeon General, Department of Transportation,Public Health Service, Environmental Protection Agency, and the National Research Council all indicated that little data is available for other than Threshold Limit Values (TLV) for the compounds.

The TLV represents conditions under which nearly all workers may be repeatedly exposed day after day without adverse effects. In very few instances have the values been firmly established on a basis of examination of human subjects correlated with adequate environmental observations. A list of TLV's is published annually by the American Conference of Governmental Industrial Hygienists. A listing of the TLV's and other documented responses and associated concentrations are shown in Appendix B.

Establishing buffer zones at distances where the TLV concentrations occur is considered unrealistic. It is impractical to require buffer zones to insure that a person could work in the resulting atmosphere eight hours a day, every day without adverse effects. An analysis of the available data indicates that concentration levels of 4 to 6 times the TLV levels can be tolerated without acute discomfort. Except for Acetic Acid and Ammonia, the limits contained in Table 3 are 4 times the TLV for each compound. For Ammonia and Acetic Acid, the values at which discomfort occurs were used. Limited exposure of 30 minutes or less to these concentrations, at worst, should cause eye and nasal irritation among the average population. These limits are believed sufficiently low so that exposure will not prevent self-rescue operations such as walking out of the area.

TABLE 3. CONCENTRATION LEVELS

Compound	Recommended Concentration	TLV
Acetic Acid (Glacial)	60 mg/m^3	24 mg/m^3
Acetic Anhydride	80 mg/m^3	20 mg/m^3
Ammonia	210 mg/m^3	35 mg/m^3
Nitric Acid	100 mg/m^3	25 mg/m^3
Sulfuric Acid	4 mg/m^3	1 mg/m^3

RESULTS

Depending upon the area covered when a spill occurs, the distances shown in Table 4 are the minimum distances required to insure that the civilian populace is not exposed to a higher concentration than those shown in Table 3. Downwind hazard distances for a variety of concentration levels, wind speeds, and meteorological conditions are shown in Appendix C.

TABLE 4. DOWNWIND EXCLUSION DISTANCE[a]
(Meters)

	Spill Area (Sq. Ft.)				
Compound	200	400	600	800	1000
Acetic Acid (Glacial)	890	1410	1800	2240	2660
Acetic Anhydride	30	50	65	80	90
Ammonia	1250	1960	2720	3350	3850
Nitric Acid	130	200	260	320	370
Sulfuric Acid	160	260	350	420	490

[a]These distances are based on worst-case conditions; i.e., 2 mph windspeed; 86°F; inversion.

SUMMARY

The quantity of physiological response data available for common chemical compounds is not adequate to determine the first element of input when establishing hazard distances; i.e., dosage levels. This data must be determined before accurate hazard distances can be established. However, in view of the impending decision at Volunteer AAP, buffer zones could be based upon concentrations that are believed to be within short exposure tolerances for the average populace. Once a concentration level is established, the downwind exclusion distance can be obtained from the appropriate table in Appendix C.

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3. American Industrial Hygiene Association, Hygienic Guide Series, Detroit, Michigan.

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5. US Department of Health, Education, and Welfare, The Toxic Substances List, 1973 Edition.

6. Irving Solomon et al, ORG Report 40, Methods of Estimating Hazard Distances for Accidents Involving Chemical Agents, February 1970. CONFIDENTIAL.

7. Hazards of Chemical Rockets and Propellants Handbook, Volume III, CPIA/194, Chemical Propulsion Information Agency, Silver Spring, Maryland, May 1972.

APPENDIX A. EVAPORATION RATE

The method for calculating the evaporation rates for liquid compounds was taken from the Chemical Engineers' Handbook, 3rd Edition, Section 8 (General Theory of Diffusional Operations).

The procedure used for the calculations is as follows:

a. Determine the Reynolds number (dimensionless), N_{Re}, for the air flow from the equation

$$N_{Re} = Lv\rho/\mu,$$

where

L = downwind length of the puddle, ft

v = wind speed, ft/min

ρ = density of the air, lb/ft^3

μ = viscosity of the air, lb/(ft-min)

b. From the Reynolds number, calculate the mass transfer factor, j_M, as follows:

$$j_M = 0.664\left(N_{Re}\right)^{-0.5} \qquad \text{for } N_{Re} \leq 20{,}000$$

$$j_M = 0.036\left(N_{Re}\right)^{-0.2} \qquad \text{for } N_{Re} > 20{,}000$$

c. Derive the mass transfer coefficient, which is defined by

$$\frac{k_G}{G_M} = j_M\left(\frac{\mu}{\rho D}\right)^{-2/3},$$

where

k_G = mass transfer coefficient, lb moles/(min) (ft^2) (mole fraction)

G_M = molar mass velocity of air = $v\rho/M_A$, lb moles/(min) (ft^2)

M_A = molecular weight of air, lb/lb mole

$\frac{\mu}{\rho D}$ = Schmidt number (dimensionless)

D = diffusivity, ft^2/min

The diffusivity of agent vapor in air may be computed from

$$D = 0.0003 \frac{T^{3/2}}{P(V_A^{1/3} + V_B^{1/3})^2} \left(\frac{1}{M_A} + \frac{1}{M_B}\right)^{1/2}$$

d. Compute the evaporation rate, E, from the relationship

$$E = \left(k_G\right)\left(\frac{M_B}{M_A}\right)\left(\frac{p_B}{P}\right) = \frac{\text{lb of agent}}{\text{(min) (square foot)}},$$

where

p_B = vapor pressure of compound at liquid-air interface.

P = pressure corresponding to one atmosphere in units equivalent to p_B.

APPENDIX B. TOXICOLOGICAL DATA

Acetic Acid

"Atmosphere concentrations immediately hazardous to life: unknown for humans. The LC_{50} in mice is reported to be 5620 ppm for a one hour exposure. A 4 hour exposure to 16,000 ppm killed one of six rats." (Ref 3, Acetic Acid, Sept 1972).

TLV = 10 ppm = 24.5 mg/m^3

No one will voluntarily remain in concentrations of 50 ppm (122.6 mg/m^3). 25 ppm (61.3 mg/m^3) will cause extreme eye and nasal irritation in unacclimated humans. (Ref 3, Acetic Acid, para 3.11).

Acetic Anhydride

"Death occurs in 5 minutes among rats exposed to saturated vapor." (Ref 3, Acetic Anhydride, Jan 1971)

"Rats exposed for 4 hours to 2,000 ppm were all dead within 14 days while rats exposed for 4 hours to 1,000 ppm all survived the 14 day observation period." (Ref 3, Acetic Anhydride, Jan 1971)

"The effects of exposure were so marked that workmen could not endure an atmosphere of 800 ppm for longer than 3 minutes." (Ref 2, p. 203)

(LCLO = Lowest Published Lethal Concentration in Air)

Rat - LCLO = 1,000 ppm for exposure less than 24 hours.

TLV = 5 ppm

Ammonia

"Exposed rabbits and cats to static atmospheres with initial concentrations on the order of 5,000 to 10,000 ppm ammonia, for 1 hour, and found this exposure to be approximately the LC_{50}." (Ref 1, p. 861)

Physiological Response to Ammonia
(Ref 1, p. 862)

Response	Concentration (ppm)
Maximum concentration for prolonged exposure	100
Maximum amount for 1 hour	300-500
Least amount causing immediate irritation of eyes, nose, and throat	400-700
Dangerous for as little as 1/2 hour	2500-6500
Rapidly fatal for short exposures	5000-10,000

TLV = 50 ppm = 35 mg/m^3

From Ref 4, SD-8, para 8-1.2

.6 to 1% by volume is lethal within few minutes
.05 to .1% by volume is irritating to eyes, respiratory tract and throat
.2% produces convulsive coughing and may be fatal within 1/2 hour
2% is maximum concentration tolerated by the skin for more than few seconds

From Ref 6, p. 3-2

10 min. EEL - 350 mg/m^3 - 500 PPM

30 min. EEL - 210 mg/m^3 - 300 PPM

60 min. EEL - 210 mg/m^3 - 300 PPM

Nitric Acid (99%)

"Pulmonary edema may follow exposures for only 1/2 to 1 hour to higher concentrations (100-150 ppm). A few breaths of the gaseous oxides in a concentration of 200-700 ppm will cause severe pulmonary damage which may prove fatal within 5 to 8 hours." (Ref 4, SD-5, p. 15)

For white fuming: Rat - LC_{50} = 244 ppm (Ref 5, p. 656)

TLV = 10 ppm/8 hr = 25 mg/m^3

Sulfuric Acid

"The 2.5μ droplets caused the greatest response in the higher levels of concentration and at 200 mg/m^3 caused death within one hour to all 4 animals (guinea pigs) exposed to this concentration." (Ref 1, p. 896)

"Short Exposure Tolerance: 18 mg/m^3 in the form of 1μ diameter droplets killed 50% of exposed guinea pigs in eight hours, while more than 500 mg/m^3 were required for mice." (Ref 3, Sulfuric Acid, 2nd printing, April 1964).

(LCLO = Lowest Published Lethal Concentration in Air)
Rat - LCLO = 500 mg/m^3 for exposure less than 24 hours.
Mouse - LCLO = 549 mg/m^3 for exposure of 3.5 hours.
Guinea Pig - LCLO = 165 mg/m^3 for exposure of 0.25 hours. (Ref 5, p. 897)

5 mg/m^3 is distinctly objectionable to humans and can be tolerated for 5 minutes maximum. (Ref 3)

TLV = 1 mg/m^3

TABLE B-1. SUMMARY OF HUMAN TOXICOLOGY DATA

AGENT	CONCENTRATION	EFFECT
Acetic Acid (Glacial)	24.5 mg/m^3 (10 PPM)	TLV
	61.3 mg/m^3 (25 PPM)	Unacclimated humans experience eye and nasal irritation
	122.6 mg/m^3 (50 PPM)	No one will voluntarily remain
Acetic Anhydride	20 mg/m^3 (5 PPM)	TLV
	3337.4 mg/m^3 (800 PPM)	Fatal in 3 minutes
Ammonia	35 mg/m^3 (50 PPM)	TLV
	210 mg/m^3 (300 PPM)	30-60 min. Emergency Evacuation Limit (EEL)
	350 mg/m^3 (500 PPM)	10 min. EEL
Nitric Acid	25 mg/m^3 (10 PPM)	TLV
	64.4 mg/m^3 (25 PPM)	Pulmonary signs and symptoms after an 8 hr. exposure
	257.7-386.5 mg/m^3 (100-150 PPM)	Pulmonary edema after 1/2 to 1 hour exposure
Sulfuric Acid	1 mg/m^3	TLV
	5 mg/m^3	Distinctly objectionable (can be tolerated for 5 min max)

APPENDIX C. DOWNWIND EXCLUSION DISTANCES

Downwind exclusion distances were calculated for these five common chemical compounds:

1. Glacial Acetic Acid (Table C-1)

2. Acetic Anhydride (Table C-2)

3. Ammonia (Table C-3)

4. Nitric Acid (Table C-4)

5. Sulfuric Acid (Table C-5)

Calculations were made for all combinations of the following:

1. Temperature : 86°F (30°C)

2. Windspeed: 2, 5, 10, 15 m.p.h.

3. Weather Condition: inversion, neutral

4. Spill area: 200, 400, 600, 800, 1000 square feet

The chemicals were assumed to evaporate in a pure state.

TABLE C-1. DOWNWIND EXCLUSION DISTANCES (METERS) FOR GLACIAL ACETIC ACID

			METEOROLOGICAL CONDITIONS							
			INVERSION				NEUTRAL			
WIND SPEED (M.P.H.)	PUDDLE SIZE (Sq. Ft.)	EVAPORATION RATE (Lb./Min.)	CONCENTRATION LEVEL (Mg/M^3)				CONCENTRATION LEVEL (Mg/M^3)			
			120	90	60	25	120	90	60	25
2	1000	45	1580	1950	2660	5100	630	750	940	1560
2	800	37	1330	1680	2240	4400	560	670	740	1370
2	600	28	1120	1380	1800	3550	490	560	710	1170
2	400	20	840	1000	1410	2690	400	470	550	990
2	200	11	530	640	890	1680	280	330	420	690
5	1000	93	1360	1680	2280	4470	570	660	840	1390
5	800	76	1140	1420	2000	3900	500	590	740	1660
5	600	59	960	1190	1600	3160	440	520	640	1080
5	400	41	720	890	1250	2420	360	420	530	890
5	200	22	450	560	780	1490	250	300	370	620
10	1000	162	1220	1520	2000	3980	520	620	790	1280
10	800	133	1060	1270	1780	3530	460	550	700	1140
10	600	102	860	1080	1410	2820	400	480	610	1000
10	400	71	650	800	1120	2160	330	390	500	800
10	200	38	410	500	700	1340	230	270	350	570
15	1000	224	1240	1490	2020	3980	520	620	790	1210
15	800	183	1000	1240	1680	3170	450	530	670	1100
15	600	142	800	1000	1390	2660	390	460	560	960
15	400	98	610	760	1010	2000	320	370	460	790
15	200	53	380	470	630	1260	220	260	330	550

TABLE C-2. DOWNWIND EXCLUSION DISTANCES (METERS) FOR ACETIC ANDYDRIDE

			METEOROLOGICAL CONDITIONS							
			INVERSION				NEUTRAL			
WIND SPEED (M.P.H.)	PUDDLE SIZE (Sq. Ft.)	EVAPORATION RATE (Lb./Min.)	CONCENTRATION LEVEL (Mg/M^3)				CONCENTRATION LEVEL (Mg/M^3)			
			200	120	80	20	200	120	80	20
2	1000	0.75	45	65	90	260	40	55	70	160
2	800	0.61	40	55	80	230	35	50	65	140
2	600	0.47	30	45	65	190	30	45	55	125
2	400	0.33	25	35	50	140	25	35	45	105
2	200	0.18	15	25	30	90	20	25	35	70
5	1000	1.56	35	55	80	230	35	50	65	145
5	800	1.27	30	50	65	200	30	45	55	130
5	600	0.98	25	40	55	170	25	35	50	110
5	400	0.68	20	30	45	125	20	30	40	90
5	200	0.37	15	20	25	80	15	20	30	65
10	1000	2.71	35	50	70	210	30	45	55	130
10	800	2.22	30	45	60	180	30	40	50	125
10	600	1.71	25	35	50	140	25	35	45	100
10	400	1.19	20	30	40	110	20	30	35	90
10	200	0.64	12	20	25	70	15	20	25	60
15	1000	3.75	30	45	65	200	30	45	55	125
15	800	3.07	25	40	55	165	25	40	50	115
15	600	2.37	20	35	50	140	25	35	45	100
15	400	1.64	20	25	35	105	20	30	35	80
15	200	0.88	10	15	20	65	15	20	25	55

TABLE C-3. DOWNWIND HAZARD DISTANCES (METERS) FOR AMMONIA

WIND SPEED (M.P.H.)	PUDDLE SIZE (Sq. Ft.)	EVAPORATION RATE (Lb./Min.)	METEOROLOGICAL CONDITIONS: INVERSION, CONCENTRATION LEVEL (Mg/M^3) 350	210	150	35	NEUTRAL, CONCENTRATION LEVEL (Mg/M^3) 350	210	150	35
2	1000	258	2600	3850	5000	15200	890	1260	1580	3550
2	800	211	2240	3350	4200	12500	790	1120	1250	3160
2	600	163	1770	2720	3550	10600	700	975	1120	2700
2	400	113	1410	1960	2660	7950	560	800	950	2240
2	200	61	900	1250	1590	5010	400	570	630	1590
5	1000	538	2240	3210	4230	12590	840	1120	1380	3160
5	800	440	2020	2830	3560	11220	750	1000	1250	2820
5	600	340	1580	2380	3060	9200	640	870	1100	2500
5	400	236	1230	1780	2230	7080	510	710	880	1900
5	200	126	760	1120	1420	4430	360	500	620	1410
10	1000	936	2000	3060	3970	11800	780	1040	1260	2820
10	800	766	1780	2600	3360	1000	700	930	1120	2510
10	600	591	1420	2170	2820	8000	600	780	1000	2240
10	400	410	1120	1610	2100	6300	480	650	790	1780
10	200	220	700	1000	1310	3980	340	470	560	1260
15	1000	1295	2000	2820	3550	11220	720	1000	1220	2780
15	800	1059	1570	2350	3160	9600	660	890	1080	2480
15	600	818	1350	1990	2500	7940	570	750	920	2110
15	400	568	1000	1520	2000	5650	460	630	760	1720
15	200	304	630	950	1260	3550	320	440	510	1200

TABLE C-4. DOWNWIND EXCLUSION DISTANCES (METERS) FOR NITRIC ACID

			METEOROLOGICAL CONDITIONS							
			INVERSION				NEUTRAL			
WIND SPEED (M.P.H.)	PUDDLE SIZE (Sq. Ft.)	EVAPORATION RATE (Lb./Min.)	CONCENTRATION LEVEL (Mg/M^3)				CONCENTRATION LEVEL (Mg/M^3)			
			150	100	85	25	150	100	85	25
2	1000	5.78	270	370	500	1100	160	210	290	500
2	800	4.73	220	320	450	900	150	190	250	440
2	600	3.65	200	260	370	770	130	160	210	370
2	400	2.54	150	200	280	580	100	130	170	310
2	200	1.36	90	130	170	360	70	90	130	210
5	1000	12.03	240	320	450	990	150	190	250	440
5	800	9.85	200	280	390	810	140	170	220	390
5	600	7.60	170	230	320	660	120	150	190	340
5	400	5.28	130	170	240	500	90	120	150	270
5	200	2.83	80	110	150	320	60	80	100	190
10	1000	20.95	210	280	400	840	140	180	220	400
10	800	17.14	180	250	360	720	120	150	200	360
10	600	13.23	150	200	280	600	110	130	180	310
10	400	9.19	110	150	220	450	80	110	140	250
10	200	4.92	70	90	140	280	60	80	100	180
15	1000	28.98	200	270	390	790	130	170	210	390
15	800	23.70	170	230	330	700	110	150	190	320
15	600	18.30	140	190	260	560	100	130	170	280
15	400	12.71	100	140	200	430	80	100	140	230
15	200	6.80	60	90	130	260	60	70	100	160

TABLE C-5. DOWNWIND EXCLUSION DISTANCES (METERS) FOR SULFURIC ACID

			METEOROLOGICAL CONDITIONS							
			INVERSION				NEUTRAL			
			CONCENTRATION LEVEL (Mg/M^3)				CONCENTRATION LEVEL (Mg/M^3)			
WIND SPEED (M.P.H.)	PUDDLE SIZE (Sq. Ft.)	EVAPORATION RATE (Lb./Min.)	5	4	3	1	5	4	3	1
2	1000	0.33	410	490	620	1400	230	260	310	590
2	800	0.27	360	420	510	1130	200	230	280	530
2	600	0.21	290	350	440	1000	180	200	240	450
2	400	0.14	220	260	330	710	140	160	200	360
2	200	0.08	140	160	210	460	100	110	130	250
5	1000	0.68	360	430	530	1210	210	230	280	530
5	800	0.56	310	360	450	1060	180	210	240	470
5	600	0.43	250	350	380	870	160	180	220	410
5	400	0.30	190	230	280	640	130	150	170	330
5	200	0.16	110	141	180	320	90	100	120	230
10	1000	1.18	320	380	480	1050	190	210	250	490
10	800	0.97	270	330	410	950	170	200	230	440
10	600	0.75	230	270	340	730	150	160	200	380
10	400	0.52	170	200	250	590	120	130	160	280
10	200	0.28	110	130	160	370	75	90	110	220
15	1000	1.64	290	360	450	1040	180	210	240	460
15	800	1.34	260	330	380	890	160	190	220	420
15	600	1.03	210	250	320	740	140	160	180	360
15	400	0.72	160	190	240	530	110	130	150	280
15	200	0.38	100	120	150	340	80	90	110	200